INSTRUCTION MANUAL

REGULATED POWER SUPPLIES

LR SERIES

QUARTER-RACK MODELS

LAMBDA

LAMBDA ELECTRONICS CORP.-MELVILLE, L. I., N. Y.

PRELIMINARY

INSTRUCTION MANUAL

FOR

REGULATED POWER SUPPLIES

LR SERIES

QUARTER-RACK MODELS

This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics Corp. All information contained herein applies to all models.

LAMBDA ELECTRONICS CORP. MELVILLE, L.I., N.Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

IM LR60

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SPECIFICATIONS AND FEATURES

The following specifications apply for all metered LR quarter-rack models

DC OUTPUT--Voltage regulated for line and load

Voltage Range .....

TABLE I

VOLTAGE RANGE

MODEL	LR-602FM	LR-603FM	LR-605FM	LR-606FM
VOLTAGE RANGE VDC	0-20	0-40	0-120	0-250

Multi-Current Ranges ..... Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range with input frequency 55-65 Hz. Derate current 10% for 50 Hz input frequency.

TABLE II

CURRENT RANGE

MODEL	CURRENT RATING AT AMBIENT OF:			
	30°C	40°C	50°C	60°C
LR-602FM	1.1A	0.95A	0.80A	0.64A
LR-603FM	0.60A	0.50A	0.42A	0.33A
LR-605FM	0.23A	0.20A	0.17A	0.14A
LR-606FM	80 ma	72 ma	65 ma	60 ma

REGULATED VOLTAGE OUTPUT

Regulation (line) ..... 0.0005 percent plus 100 microvolts for input variations from 105-132 or 132-105 volts AC

Regulation (load) ..... 0.0005 percent plus 100 microvolts for load variations from 0 to full load or full load to 0

Remote Programming

External Resistor ..... 1000 ohms/volt output

Programming Voltage ..... One-to-one voltage change

Accuracy ..... 0.01% plus 1.0 millivolt at 25°C

Stability ..... 0.001% plus 100 microvolts over any 8-hour period, after initial 30-minute warmup time

Ripple and Noise ..... 35 microvolts rms, 100 microvolts p-to-p with DC-30KHz bandwidth, with either positive or negative terminal grounded, with 60 Hz input

Temperature Coefficient ..... Change in output voltage 0.001% plus 10 microvolts/°C

DC OUTPUT--Current regulated for line and load; automatic crossover with voltage limit

Multi-Current Ranges ..... Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range. Maximum current 100% of 30° rating in Table II; minimum current 1% of 30° rating in Table II.

Voltage Range ..... For voltage range see Table I; voltage ratings apply for entire current range.

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line) ..... Less than 2.0 milliamperes, for input variations from 105-132 or 132-105 volts AC

Regulation (load) ..... Less than 2.0 milliamperes, for load voltage changes from 0 to rated VDC or rated VDC to 0 volts.

AC INPUT--105-132 volts AC at 47-440 Hz; for input power see Table III. Ratings apply for 55-65 Hz; for other input frequencies consult factory.

TABLE III

INPUT POWER, WATTS*

INPUT POWER	MODEL
65 W	LR-602FM
65 W	LR-603FM
75 W	LR-605FM
60 W	LR-606FM

*With output loaded to full 30°C rating and input voltage 132 volts at 55-65 Hz.

OVERLOAD PROTECTION

Thermal ..... Thermostat, resets automatically when over-temperature condition is eliminated.

Electrical

External Overload Protection ... Adjustable, automatic, electronic current limiting circuit, settable to 105 percent of rated current; limits output current to preset limit for protection of load and power supply when external overloads and short circuits occur

Internal ..... "SLO-BLO" 1-1/2A fuse F1 protects the AC input circuit. Overload of the supply does not cause fuse failure.

"SLO-BLO" fuse F2 protects the load from excessive output current that can be caused by internal circuit failure

TABLE IV
F2 RATINGS

MODEL	RATING (AMPS)
LR602FM	2-1/2 A
LR603FM	1-1/2 A
LR605FM	1/2 A
LR606FM	1/4 A

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal blocks on rear of chassis with 5-foot, 3-wire detachable line cord for all models.

OVERSHOOT - No overshoot of output voltage under conditions of power turn-on, power turn-off, or power failure.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from 0° to 60° ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE - (non-operating) -55°C to +85°C

METERS-Voltmeter and ammeter on all models

CONTROLS

DC output controls ..... Coarse and fine voltage controls and coarse and fine current controls permit adjustment of DC output; located on front panel of all models.

Binding Posts (+) (-) (GND)..... Five-way binding posts on all models.

Remote Sensing ..... Provision is made on rear terminal block for remote sensing which eliminates effect of power output lead resistance on DC regulation.

Power	Panel mounted switch and indicator light for all units. When switch is in the ON position the red ON indicator lamp glows.

PHYSICAL DATA

Size.....	5-3/16"H x 4-3/16W x 15-1/2"D
Weight	11 lbs. net; 14 lbs. shipping wt.
Panel Finish	Brushed aluminum clear anodized panels with grey inlay (standard); special finishes available to customer's specifications at moderate surcharge.

MOUNTING

Laboratory bench, table top	Bumpers secured to the base of all LR models permit proper circulation of air through the unit. Removal of bumpers will restrict free-flow of air through the unit; avoid removing bumpers.
Standard 19" Rack	All LR units can be used with rack adapters LRA-1 and LRA-2

ACCESSORIES

Rack Adapters	Rack adapter LRA-1 used for ruggedized mounting, with or without chassis slides, is available, as well as rack adapter LRA-2 which is used for simple rack installations where chassis slides are not required. See figure 14.
Blank Panels	Half-rack and quarter-rack panels
Overvoltage Protector	Externally mounted overvoltage protectors LHOV-4, LHOV-5 are available for use with Lambda LR power supplies LR-602FM, LR603FM. The overvoltage protector prevents damage to the load that can be caused by excessive power supply output voltage.

MODEL OPTIONS

Suffix "V" Input Option	Standard LR power supplies can be obtained for operation with 205-265 volt, 55-65 Hz input; for 47-57 Hz derate current 10%

Suffix "R" Fungus Proofing Option .... Standard LR power supplies can be obtained with fungus proofing treatment with MIL V 173 varnish for all fungi nutrient components.

THEORY OF OPERATION

GENERAL

The Lambda power supply consists of an AC input circuit and transformer; a bias supply consisting of auxiliary rectifiers and filter and a reference source comprised of a current-regulator reference zener, amplifier and series regulator; a main regulator circuit consisting of the main rectifier and filter, a series regulator, emitter follower driver(s), a voltage control circuit comprised of voltage comparator, amplifier and constant current source, a current regulator circuit comprised of a current comparator and constant current source, current and voltage sensing networks and an oven control circuit comprised of a driver, series regulator and a transistor used to sense oven temperature changes.

FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing a built-in thermostat S2 and fuse F1, which protect the supply against overheating and internal faults.

Main full-wave rectifiers CR23 and CR24 (or CR17, CR18) provide the power which is filtered by capacitor C8 and then regulated via a series regulator and delivered to the output.

Auxiliary full-wave rectifiers CR1, CR2 provide the power for the first driver, reference source, oven control circuit, voltage control circuit and current regulator circuit. The reference source consists of input capacitor C1, which filters the rectified current, and a regulated current source comprised of Q1, Q2, CR4, CR5 and R1. The regulated current is converted into a constant voltage by zener diode CR10, which acts as a bias source for the current regulator and voltage control circuits and as a pre-regulator for the voltage reference zener CR12. CR7 provides a negative bias for voltage comparator Q7A and B.

The collector currents of Q4A and Q5A are regulated by constant-current source transistors Q4B and Q3 respectively.

The voltage control and reference circuitry is located in a proportional control oven which keeps the circuit elements in a constant ambient temperature. The oven control circuit is comprised of transistors Q8, Q10, Q11 and temperature sensing thermistor RT1. Overtemperature thermostat S3 is used to protect the voltage control circuitry if failure of the oven control circuitry occurs.

Constant voltage or constant current crossover circuit operation is determined by changes in the load. A change in the output voltage is sensed by sensing divider R68A, B, which has a constant current of 1 milliampere flowing in the divider element, determined by resistors R55 thru R63 and the setting of calibration control R28. This output voltage variation causes a change to the input of voltage comparator Q7A, B, which compares it with the reference voltage determined by CR12, resulting in an error signal at the output of Q7A, B. In constant voltage operation, the voltage across R54 is less than the preset voltage across R9A, B; CR9 is at cutoff; Q5A is in saturation and CR11 is con-

ducting. If the load current decreases, causing a rise in output voltage, Q7B conducts more, Q7A is biased toward cutoff and the current from R22 flows through OR gate diode CR11 instead of Q7A. This action causes amplifier Q4A to conduct more heavily, reducing drive current to the bases of drivers Q13, 14, 15 (and Q12 for LR605, 606), causing the series regulator impedance to increase and the output voltage to decrease accordingly.

Simultaneously, Q5B of the current comparator samples the load current through current sensing resistor R54 and compares it with the reference voltage across current sensing divider R7, R8 and R9A, B, determined by zener diode CR10. In constant current crossover operation, when the increasing voltage across R54 is approximately equal to the preset voltage across R9A, B, Q5B will conduct harder and bias Q5A toward cutoff, causing the current from Q3 to flow through OR gate diode CR9 instead of Q5A. Similarly, this action will cause amplifier Q4A to conduct more heavily, reducing drive current to the bases of Q13, 14, 15 and, as applicable, Q12, causing the series regulator impedance to increase and the output current to decrease accordingly, effectively maintaining a constant current. Accordingly, the output voltage decreases and is sensed by the voltage sensing network, causing Q7B to be reverse biased, turning it off and causing turn-on of Q7A untill saturation occurs and OR gate CR11 stops conducting. The unit now continues to function in the constant current mode of operation with OR gate diode CR9 controlling the turn-on bias of Q4A, which in turn controls the drive current to the series regulator and ultimately the output current of the supply.

In models LR605, LR606 tandem transistors Q16, Q17 are used to share the total series regulator voltage. Resistors R11 and R37 fix the bases of Q20 and Q21 at approximately one-half of the total series regulator voltage. The emitter current from Q21 controls tandem regulator Q17, which tracks with Q16 to split voltage and power. For example, when voltage across Q16 increases due to a regulating action, the current in R11 and R37 also increases, causing base of Q20 to be biased toward cutoff which in turn biases Q21, Q17 toward cutoff so that the voltage across Q17 increases until the voltage across Q17 and Q16 are approximately equal.

In models LR602, LR603, the Icbo of Q16 is controlled by resistors R45 and diode CR16 or CR21 (also CR22 in LR603). In models LR605, LR606 the Icbo of Q16 is controlled by transistor Q18 (and Q19 for LR606), resistor R49 and diodes CR25, CR26. Diode CR21 or, as applicable, CR16 and CR22 also function(s) in all models to prevent overshoot after "turn-off" and to protect the supply against reverse current when used in a parallel operation connection.

CONTROLS, INSTRUMENTS AND FUSES

ON-OFF Switch. The ON-OFF switch, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red indicator glows.

OUTPUT VOLTAGE Control. The OUTPUT VOLTAGE control is a dual control consisting of coarse and fine adjustment potentiometers which vary the DC voltage over the rated voltage range for the unit. For models LR-602FM and LR-603FM the range of the fine control is one volt; for models LR-605FM and LR-606FM the range is two volts. Clockwise rotation results in increasing voltage. The total DC voltage output for voltage regulated operation is equal to the combined settings of each shaft; for current regulated operation, the voltage compliance (maximum voltage limit) is equal to the combined setting of the coarse and fine voltage controls.

CURRENT LIMITER Control. The CURRENT LIMITER control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC current over 90% of the rated current range* and a fine adjustment potentiometer, which varies the DC current over 10% of the rated current range.* Clockwise rotation results in increasing current. The total DC current output for current regulated operation, is equal to the sum of each shaft setting; for voltage regulated operation the maximum current limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

* Operation for output current below rated limits can result in no output or no regulation.

Output Voltage Meter. A DC voltmeter monitors the voltage at the output terminals of all units for the rated voltage range.

Output Current Meter. A DC ammeter monitors the load output current of all units for the rated current range.

Fuses. Fuse F1, internally located, is a 1-1/2 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Fuse F2, internally located, provides load protection against internal circuit failure. See Table IV for current ratings of pertinent F2 fuse.

Connection Terminals. Make all connections to the supply at the terminal blocks on the rear of the supply. DC output connections can also be made at the five-way binding posts located on the front panel of all models. If the line cord is removed, apply input power through the line cord or directly to terminals 1 and 2 of the short terminal block. Always connect the ungrounded (hot) power lead to terminal 1.

On the long terminal block the supply positive terminal is brought out to terminal 6. The supply negative terminal is brought out to terminal 4. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 10. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the rear output terminals.

GROUND CONNECTIONS

The Lambda power supply can be operated either with negative or positive output terminal grounded or with no terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

> NOTE: When operating the supply with neither terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

BASIC MODES OF OPERATION

This power supply is designed to operate as a constant voltage source or as a constant current source. Automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant voltage source while the load current does not equal the current value, I_{LIM}, set by the CURRENT LIMITER control. When load current $I_L = \frac{V}{R_L} = I_{LIM}$, the supply will cross over automatically and will operate as a constant current source. Further decrease in value of load resistance R_L results in decrease of voltage across the load while current remains regulated to I_{LIM}.

Constant Current (Automatic Crossover). The power supply will function as a constant current source while the load voltage V_L does not equal the voltage set by the OUTPUT VOLTAGE control. When load voltage V_L equals the value set by the OUTPUT VOLTAGE control, the supply will automatically cross over and operate as a constant voltage source.

SUPPLY-LOAD CONNECTIONS

> NOTE: Refer to DETAILED OPERATING PROCEDURES for step-by-step instructions for operation of power supply.

CONNECTIONS FOR OPERATION AS A CONSTANT VOLTAGE SOURCE

The regulation of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on this characteristic, remote sensing is used. Recommended types of supply-load connections with local or remote sensing are described in the following paragraphs.

Refer to figure 1 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 2.

Two-Wire Connection, Figure 3. The two-wire connection with local sensing, provides simplest connection suitable for applications with relatively constant load.

Four-Wire Connection, Figure 4. The four-wire connection with remote sensing, provides complete compensation for the DC voltage drops in the connecting cables. Compensation for lead drop is also valid for gradual changes of load current.

Programmed Voltage Connections, Using External Resistor, Figure 5. Discrete voltage steps can be programmed with a resistance voltage divider valued at 1000 ohms/volt output and a shorting-type switch as shown in figure 5. When continuous voltage variations are required, use a variable resistor with the same 1000 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation. Connect a low-leakage, 2 mfd, 400 VDC mylar capacitor to terminal 8 and 4 to reduce any ripple picked up by the external programming leads.

As shown in figure 5, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 6. The power supply output voltage can be programmed with an externally connected programming power supply. The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

The programming supply must have a reverse current capability of 1 MA minimum.

Alternatively, when supplies with less than 1 MA reverse current capability are used, a resistor capable of drawing 1 MA at the minimum programming voltage must be connected across the output terminals of the supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

CONNECTIONS FOR OPERATION AS A CONSTANT CURRENT SOURCE

Automatic Crossover Constant Current Connections, Figure 3. Figure 3 shows the connections which are used when operating the power supply as a constant current source with automatic crossover, using local setting of current control.*

* Setting control for output currents below rated limits can result in no output or no regulation.

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the OUTPUT VOLTAGE control setting, the power supply crossover circuit will cause the unit to operate as a constant voltage supply.

CONNECTIONS FOR SERIES OPERATION

The voltage capability of LR power supplies can be extended by series operation of LR power supplies of equal or unequal voltage ratings. A maximum of 500 volts can be connected between either the +DC or -DC terminal and chassis ground.

All methods of series connection permit operation for either constant voltage or constant current with automatic crossover to either mode of operation whenever the respective limiting operating current or voltage is reached. Figures 7, 8 and 9 show connection for either local or remote sensing, when the series combination is operated for constant voltage; figures 7a, 8a and 9a show the connection required when the series combination is operated for constant current.

Series Connection, Figure 7. Two units are shown connected for series operation in figure 7. This figure shows the series connection diagrams which would be suitable for use in all applications where there is no tracking of one supply with respect to the other. Diodes CR_M and CR_S, which protect the units against reverse voltage must be capable of withstanding the maximum rated current of the units and the maximum voltage of the respective units.

Auto - Series Connection, Figure 8. Figure 8 shows the series connection diagrams suitable for applications where voltage tracking is required. In this series configuration, resistor R_{BAL} permits the (S) unit to track the (M) unit on an exact one-to-one basis, thereby eliminating the possibility of an offset voltage existing between the two units. Resistors R_S and R_M function in the voltage sensing circuits of both units, enabling the (S) unit to reference its output voltage to that of the (M) unit by the ratio of the two resistors R_S and R_M in the equation $E_S = \frac{E_M R_S}{R_M}$

The value of R_{BAL} is basically determined by the output voltage, E_M, and the percentage of tracking error desired in the series operation. Percentage of tracking error is determined by the value of resistors R_M and R_S and the maximum offset current of the (S) unit, which is 1.0 microampere. Determine percentage of tracking error using the equation:

$$\% \text{ Tracking Error} = \frac{1 \times 10^{-4}}{E_M / R_M}$$

Some tracking-error percentages are given in the following chart for typical values of E_M/R_M

E_M/R_M	% Tracking Error
100 UA	1
1 MA	0.1
10 MA	0.01

Determine R_{BAL} using the equation:

$$R_{BAL} = \frac{1 \times 10^{-6} E_M}{(E_M / R_M)\ 2}$$

Some values for R_{BAL} are given in the following chart, using typical values for E_M/R_M and E_M

E_M	E_M/R_M	R_{BAL}
250 V	10 MA	25 OHMS
250 V	1 MA	250 OHMS
20 V	10 MA	2.0 OHMS
20 V	1 MA	20 OHMS

Diodes CR_M and CR_S serve the same purpose and have the same requirements in this connection as for series connection, Figure 7.

DUAL - OUTPUT, AUTO TRACKING CONNECTION, FIGURE 9

Figure 9 shows the connection diagrams suitable for applications where voltage tracking is required when two power supplies are operating with separate loads. This operation is identical with Auto-Series Connection, Figure 8, except that in this connection two independant loads are connected while only one load is connected to both units in figure 8. Refer to the text material on Auto-Series Connection for all details relating to R_S, R_M and R_{BAL}, which also apply for this connection.

CONNECTIONS FOR PARALLEL OPERATION

The current capability of LR power supplies can be extended by parallel operation of two LR power supplies of equal* voltage capacities. The two units are shown connected for parallel operation in figure 10. One power supply designated the (M) unit controls its own output as well as the output of the second power supply, designated the (S) unit.

Unit (S) operates to regulate its current in a ratio to that of the (M) unit by comparing the current in its internal sampling resistor with that current sampled by the master internal sampling resistor. When power supplies of unequal current capacities are parallel connected the division of current supplied will be approximately equal to the ratio of the current ratings of the supplies. The 4 mf capacitor is used to prevent interaction of the units that could cause oscillation to occur.

Parallel connected units can be operated for constant voltage with local sensing as well as for constant current with automatic crossover. When operating for constant voltage, the (M) unit can automatically cross over into constant current operation.

*For applications using supplies of unequal voltage ratings, consult factory for details of operation.

DETAILED OPERATING PROCEDURES

SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT.
OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN
OPERATING OR SERVICING THE EQUIPMENT TO
AVOID SHOCK OR INJURY.

CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to supply and place ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size from figures 1 and 2 and choose desired type of supply-load connection from figures 3 and 4.

3. Connect supply to load as shown on the selected connection diagram.

> NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic crossover or as a local-sensing constant voltage source. Jumpers are connected at the factory as shown in figure 3. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Adjust OUTPUT VOLTAGE controls for the desired voltage setting.

5. Adjust the CURRENT LIMITER controls to the desired current limit setting. Refer to section on specifications for maximum current rating versus ambient temperature.

6. Apply AC power to the supply.

7. Place ON-OFF switch in ON position and check that red indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs to obtain correct meter indications.

9. Power supply is now in proper operation.

PROGRAMMED CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1 and 2. Choose desired type of supply-load connection from figures 5 or 6. Refer to paragraph on Programmed Voltage Connections.

3. Connect supply to load as shown on the selected connection diagram. As shown in figure 5, take care to use a shorting-type switch for the external programming control when several voltages are desired and the programming voltage method is not used.

4. Turn OUTPUT VOLTAGE control knobs to the extreme CCW position and adjust external programming voltage control to desired voltage setting.

5. Adjust the CURRENT LIMITER controls to the desired cirrent limit setting. Refer to section on specifications for maximum current ratings versus temperature.

6. Apply AC power to the supply.

7. Place ON-OFF switch in ON position and check that red indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER knobs and external programming voltage control to obtain correct meter indications.

9. Power supply is now operating properly.

CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

1. Remove AC power input to the supply and place ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size from figures 1 and 2 and connect load to the supply as shown in figure 3.

3. Turn the CURRENT LIMITER knobs to the desired current settings.

4. Adjust OUTPUT VOLTAGE control knobs to the desired voltage limit setting.

5. Apply AC power to the supply.

6. Place ON-OFF switch in ON position and check that red indicator is lit.

7. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs as required to obtain correct indications.

8. Power supply is now in proper operation.

SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to both units and place power ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and connect in accordance with figure 7. Refer to paragraph on Connections for Series Operation.

3. Select diodes CR_M and CR_S in accordance with instructions contained in Connection for Series Operation.

4. Set OUTPUT VOLTAGE controls of both units to obtain the desired output voltage. These settings must be the output voltage for the combination.

5. Adjust the CURRENT LIMITER controls of each unit to a setting equal to desired total current limit for the combination. Refer to section on Specification and Features for maximum current ratings versus ambient temperature.

NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

6. Apply AC power to the supplies.

7. Place power ON-OFF switches on both units in ON position and check that red power ON indicators are lit.

8. Check that output current and output voltage meters indicate desired values. As required, adjust OUTPUT VOLTAGE controls and CURRENT LIMITER controls of the units to obtain correct indications.

9. Power supplies are now in proper operation.

SERIES CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to both units and place power ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and make supply-load connections shown in figure 7A. Refer to paragraph on Connections for Series Operation.

3. Select diodes CR_M and CR_S as instructed in Connections for Series Operation paragraph.

4. Adjust CURRENT LIMITER controls of each unit to the desired setting.

5. Adjust the OUTPUT VOLTAGE controls of each supply for the desired voltage. Total voltage is the sum of the voltage settings of each unit.

NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

6. Apply AC power to the supplies.

7. Place power ON-OFF switches of both units to ON position and check that red power ON indicators are lit.

8. Check that output current and output voltage meters indicate desired values; total voltage is the sum of (M) and (S) unit voltages. As required, adjust OUTPUT VOLTAGE controls and CURRENT LIMITER controls of units to obtain correct indications.

9. Power supplies are now in proper operation

AUTO-SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the (M) and (S) units and place ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown in connection diagram, figure 8. As required, select diodes CR_M and CR_S, and R_{BAL}, R_S and R_M in accordance with instructions contained in paragraph for Auto-Series Connection.

4. Turn (M) unit OUTPUT VOLTAGE control knobs to the desired total voltage setting.

5. Adjust the CURRENT LIMITER controls of each supply to a setting equal to total current limit for the combination. Refer to section on specifications for maximum current ratings versus ambient temperature.

NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

6. Apply AC power to the supplies.

7. Place ON-OFF switches of both units in ON position and check that red indicators are lit.

8. Check that output current and output voltage meters indicate desired values; total voltage is equal to sum of (M) and (S) units. As required, adjust OUTPUT VOLTAGE control knobs of (M) unit to obtain correct indications; overload supply and adjust CURRENT LIMITER control knobs of (M) unit to obtain correct indications.

9. Power supplies are now in proper operation.

AUTO-SERIES CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to the (S) and (M) units and place ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown in connection diagram, figure 8A. As required, select resistor R_{BAL}, R_S and R_M and diodes CR_S and CR_M as instructed in paragraph for Auto-Series Connection.

4. Turn (M) unit CURRENT LIMITER control to the desired setting.

NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

5. Adjust (S) unit CURRENT LIMITER control to a current level higher than the current setting of the (M) unit.

6. Adjust the (M) unit OUTPUT VOLTAGE controls to the desired voltage limit setting for the two supplies in series.

7. Apply AC power to the supplies.

8. Place ON-OFF switches of both units to ON position and check that red indicators are lit.

9. Check that output current and output voltage meters indicate desired values; total voltage is the sum of (S) and (M) unit voltages. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs of (M) unit to obtain correct indications.

10. Power supplies are now in proper operation.

DUAL-OUTPUT AUTO-TRACKING CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the (S) and (M) units and place ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and choose desired type of supply-load connections from figure 9.

3. Connect supply to load as shown on the selected connection diagram. As required, select resistors R_{BAL}, R_S and R_M as instructed in paragraph on Auto-Series Connection.

4. Set* (M) unit output voltage for the desired voltage; (S) unit will track the (M) unit by the ratio determined by $\frac{R_M}{R_S}$.

* Output voltage can be set by using the OUTPUT VOLTAGE controls on the (M) unit or by the use of a remote programming resistor or voltage (See figures 5 and 6 respectively) when more precise voltage control is desired. When remote programming is used, connect the appropriate components as shown in figures 5 and 6, and refer to the paragraphs for remote programming.

5. Adjust CURRENT LIMITER controls of (M) and (S) units to the desired current limit for the respective unit.

6. Apply AC power to the supplies.

7. Place ON-OFF switches of both units in ON position and check that the output current and output voltage meters indicate desired values. As required, adjust OUTPUT VOLTAGE control knobs of (M) unit to obtain correct indication for both units and adjust CURRENT LIMITER control knobs of both units to obtain correct indications.

8. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to each supply and place ON-OFF switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 10.

> NOTE: When shipped from the factory, each supply is ready for use as a constant current source or as a local-sensing constant voltage source. Jumpers are connected at the factory. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage setting.

5. Set CURRENT LIMITER control on the (M) and (S) units to the position indicating the current value to be delivered by the respective unit. For full rated current at the maximum ambient temperature of operation, refer to section on specifications.

6. Apply AC power to each supply.

7. Place ON-OFF switches on (M) and (S) units in ON position and check that red indicators are lit.

8. Check that output current and output voltage meters on both (M) and (S) units indicate desired values; as required, adjust OUTPUT VOLTAGE control and CURRENT LIMITER control on (M) unit to obtain correct meter indications.

9. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to each supply and place ON-OFF switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2, and connect load to the supplies as shown in figure 10. Refer to paragraph on Connection for Parallel Operation.

3. Turn the CURRENT LIMITER knobs on (M) unit to the desired current setting.

4. Adjust OUTPUT VOLTAGE controls on the (M) unit to the desired voltage limit setting.

5. Apply AC power to each supply.

6. Place ON-OFF switches on (M) and (S) units in ON position and check that red POWER ON indicators are lit.

7. Check that output current and output voltage meters on both units indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs, as required, to obtain correct indications.

8. Power supplies are now in proper operation.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermostat Shutdown

The thermostat opens the input circuit only when the temperature of the transistor heat radiator exceeds a maximum safe value. The thermostat will automatically reset when the temperature of the radiator decreases to safe operating value. Refer to appropriate operation paragraph in DETAILED OPERATION PROCEDURE.

Fuse Shutdown

Internal failure of supply causes the fuse to clear the circuit, removing input power from the supply. Overloading of the unit will not cause fuse failure. Fuses will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse protected circuit operative.

GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on specifications and features for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumper and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 11, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an instrument that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance.

For good transistors, the forward resistance for any junction is always greater than zero.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, wherever possible, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

> NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In most cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to the measuring instrument.

3. Wherever possible use a heat sink when soldering transistors.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board never pry or force loose the part; unsolder the component by using the wicking process described below:

(a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or 16 stranded wire with 1/2 inch insulation removed.

(b) Dip the wick in liquid rosin flux.

(c) Place the wick onto the soldered connection and apply soldering iron onto the wick.

(d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.

(b) Either positive or negative terminal is connected to chassis ground.

(c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

TROUBLE SHOOTING CHART

Symptom	Probable Cause	Remedy
1. Power ON lamp DS1 does not light with power ON-OFF switch in ON position; no output voltage	No power input; power ON-OFF switch S1 defective; defective fuse F1; thermostat open, fuse F1 blown	Check power source, line cord and line cord plug; replace S1; replace F1; shut off unit, allow to cool and check ambient temperature
		Replace F1; if it blows immediately, check diodes CR23,24 (CR17,CR18) and capacitor C8, replace as necessary
2. Unable to adjust output voltage	Damaged OUTPUT VOLTAGE controls	Check R68A and R68B for shorts and/or open, replace as necessary
	Supply operating as constant current source with crossover at CURRENT LIMITER setting	Remove load and check for shorts and/or improper supply-load connections; refer to appropriate diagram for correct connections
3. Zero volts DC output, with power ON indicator lit	OUTPUT VOLTAGE controls turned fully CCW	Check OUTPUT VOLTAGE controls for proper setting and correct as necessary
	Fuse F2 open	Replace F2
	Short circuit across output of supply	Check load and load connections, correct as necessary
	Series regulator section open	Check Q16, and, as applicable, Q17 for open, replace as necessary
	Open Q4B, Q5B, Q7A, CR21, CR22, as applicable	Check Q4B, Q5A, Q7A, CR21 and CR22 as applicable for open, replace as necessary
	Emitter follower(s) open Q13, Q14 and where applicable Q12, Q15, Q20, Q21	Check Q12, Q13, Q14, Q15, Q20, Q21 as applicable for open, replace as necessary

TROUBLE SHOOTING CHART (cont'd)

(step 3 cont'd)	Current sensing resistor R54 open, or Q18 (LR605) and Q18, Q19 (LR606) shorted	Check R54 for open; replace as necessary; check Q18, Q19 for short and replace, as applicable
	Failure of voltage reference	Check CR10 and CR12 for short or CR3 for open; replace as necessary
	Q7B, Q4A or Q5B shorted	Check Q7B, Q4A or Q5B for short and replace as required
4. High ripple at line frequency or twice line frequency and unregulated DC output	Series regulator transistors shorted, emitter followers shorted; voltage amplifier shorted	Check Q12, Q13, Q14, Q15, Q16, Q17, Q20, Q21, Q7A, where applicable, for shorts and replace as necessary
	Amplifier Q4A, Q7B open	Check Q4A, Q7B for open, replace as necessary
	Line voltage too low	Check and correct AC input voltage at supply terminals
5. Same as 4, except intermittent	Foreign matter fallen into unit	Check for loose bench hardware and wire clippings that may have fallen through cover
	Emitter follower Icbo resistors or transistors open or changed value causing thermal run-a-way	Check R45, R49 values and Q18, Q19 (as applicable) and replace as necessary
6. High ripple at frequency other than line or twice line frequency	Oscillation due to defective component in filter network	Check for open C3, C4, R17 and replace defective component
7. Large spikes at output	Capacitor C9, C12 open	Replace C9, C12, as necessary
8. Output voltage unstable, with very low frequency oscillation (approx. one cycle per second)	Oven control cktry defective and overtemperature thermostat controlling oven temperature faulty	Check Q8, Q10, Q11 for short or RT1 for open. Replace as necessary

ADJUSTMENT OF CALIBRATION CONTROLS

Whenever parts are replaced, adjust calibration controls only when voltage and current indications are improper and do not reflect maximum ratings.

Potentiometers R26 (output voltage offset) and R28 (output voltage calibrate) are preset at the factory. Precision calibration is achieved through factory selection and connection of resistors R64 and R65, used with R26, and resistors R55 through R63, R27, R30, used with R28. Factory adjustment enables sufficient adjustment range for R26 and R28 to permit calibration of the output voltage for the life of the unit.

> NOTE: When CR12 and/or Q7A, B is replaced, the adjustment range of R26 and R28 may be limited so that proper calibration of R26 and R28 is not possible. If this occurs, the unit must be returned to the factory for recalibration of the fixed resistors used with R26 and R28.

Before making any adjustment of R26 and R28 allow the unit a warmup time of at least one-half hour.

> NOTE: Always perform adjustment procedures for R26 before adjusting R28.

Adjust Output Voltage Offset Calibration Control R26 as Follows:

1. Remove AC power input to the supply and place power ON-OFF switch in OFF position.

2. Refer to paragraph on "Programmed Voltage Connections Using External Resistor" and connect the unit as shown in figure 5A, with no external load.

3. Turn OUTPUT VOLTAGE controls for any voltage within the voltage rating for the power supply.

4. Connect a Nullmeter (H-P 419A or equivalent) between terminals 7 and 8 on the rear of the supply and restore AC power input to the unit.

5. Place power ON-OFF switch in ON position and allow at least one-half hour warmup time to elapse.

6. Adjust R26 for a null indication on the nullmeter of less than 50 microvolts.

7. After adjustment is completed, remove AC power input to the supply and disconnect equipment.

Adjust Output Voltage Calibrate Control R28 as Follows:

1. Remove AC power input to the supply and place power ON-OFF switch in OFF position.

2. Refer to paragraph on "Programmed Voltage Connections Using External Resistor" and connect the unit as shown in figure 5A, with no external load.

3. For the programming resistor connected in step 2 select a precision resistor with a 0.002% accuracy or better, whose resistance multiplied by the 1 ma. divider current will produce an output voltage of 10 volts minimum for the maximum rated voltage of the supply.

NOTE: Connect precision resistor directly to terminals 8 and 4 to reduce the possibility of errors that can be caused by lead resistance.

4. Connect a TVM (H-P model 3420A or equivalent) between terminals 4 and 6 on the rear of the supply and restore AC power input to the unit.

5. Place power ON-OFF switch in ON position and allow at least one-half hour warmup time to elapse.

6. Calculate output voltage using the formula:

$$1 \text{ ma.} \times R \pm 0.002\%$$

where R is the resistance of the precision programming resistor.

7. Adjust R28 until the output voltage, as indicated by the TVM, is within 0.002% of the voltage calculated in step 6.

8. After adjustment is completed, remove AC power input to the supply and disconnect equipment.

Adjust Current Calibration Control R7 as Follows:

1. Remove AC power to the supply and place ON-OFF switch in OFF position.

2. Unsolder wiper of R7 from resistor housing.

3. Set output voltage for the maximum rated voltage of the supply and CURRENT LIMITER controls fully CW.

4. Operate the power supply for constant current crossover, connected as shown in figure 3, with a short circuit across the output terminals.

5. Adjust R7 for 105% of full current rating at 30°C ambient, using any DC ammeter of one percent accuracy or better to obtain current indication.

6. After adjustment is completed remove AC power input to the supply and solder wiper R7 to potentiometer housing.

Checks With Constant Voltage Operation

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 12. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC TVM (H-P model 3420A or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power-supply line regulation accuracy on the TVM differential meter.

Use a TVM (Ballantine 320A) to measure rms ripple voltage of the power supply DC output. Use oscilloscope (Tektronix model 545 with 1A75 high-gain amplifier attachment or equivalent) to measure peak-to-peak ripple voltage of the power supply DC output.

Check With Constant Current Operation

Check the ripple or regulation of the power supply using the test connection diagram shown in figure 13. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Check the power supply load regulation accuracy while switching from the short circuit to load condition. Measure the voltage across sensing resistor Rs. Use John Fluke Model 871A or equivalent for the VTVM connected across Rs. For Rs, use a resistor having twice the value as resistor R54 in the unit being tested. To obtain regulation figure, substitute values obtained into regulation formula:

$$\frac{\Delta E}{Rs} = \text{Regulation in milliamperes,}$$

where Δ E is the voltage change in millivolts and Rs is the resistance of the sensing resistor

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power supply line regulation accuracy using VTVM and the regulation formula:

$$\frac{\Delta E}{Rs}$$

To measure rms ripple current of the power supply DC output, use a Ballantine Model 320 or equivalent meter and obtain ripple current Ir by substituting measured values into formula:

$$\frac{\text{V.A.C. rms}}{Rs} = Ir$$

SERVICE

When additional instructions are required or repair service is desired, contact the nearest office of the Lambda Electronics Corp. where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

PARTS ORDERING

Standard components and special components used in the Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.

2. Lambda part number.

3. Description of part together with circuit designation.

4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

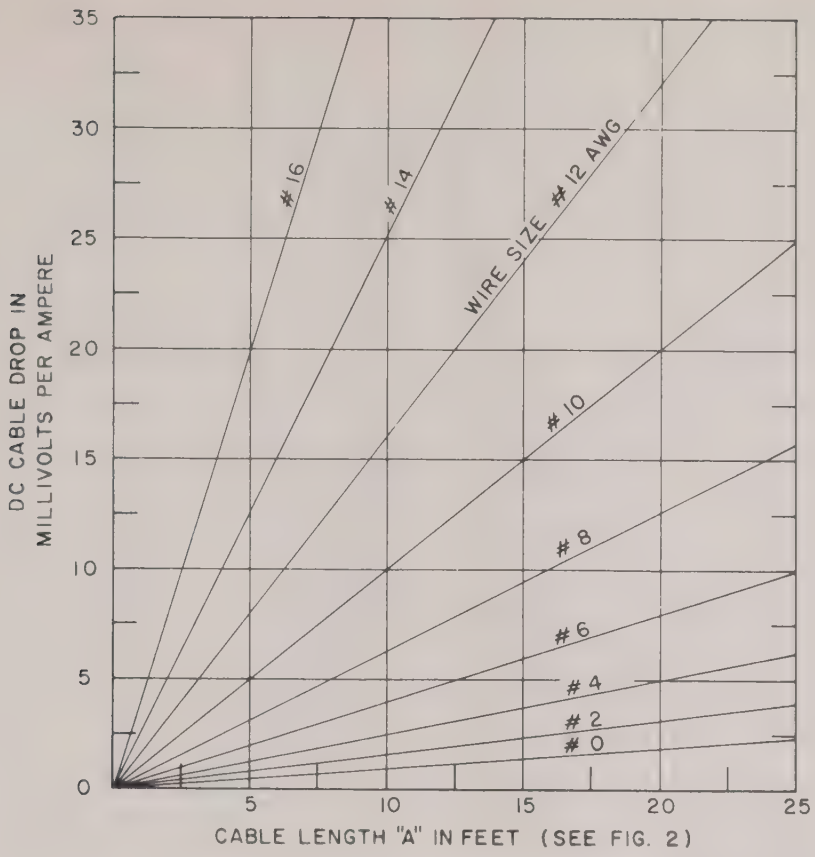


Figure 1. Cable Connection Chart

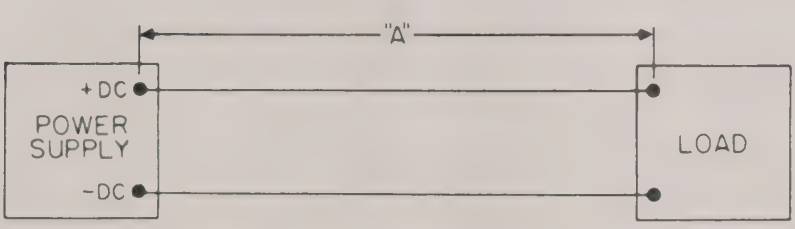


Figure 2. Cable Length "A" in Feet

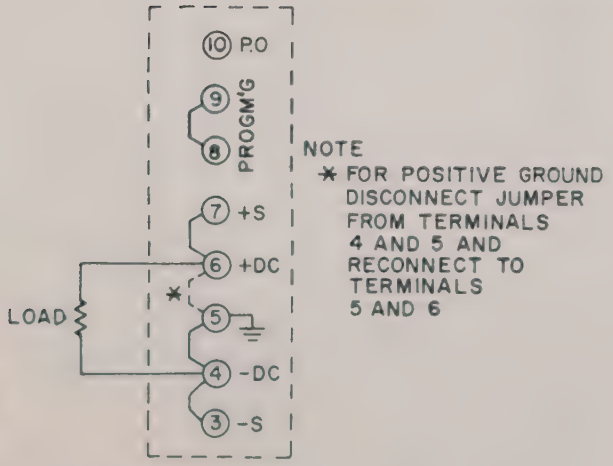


FIGURE 3. TWO-WIRE CONNECTION

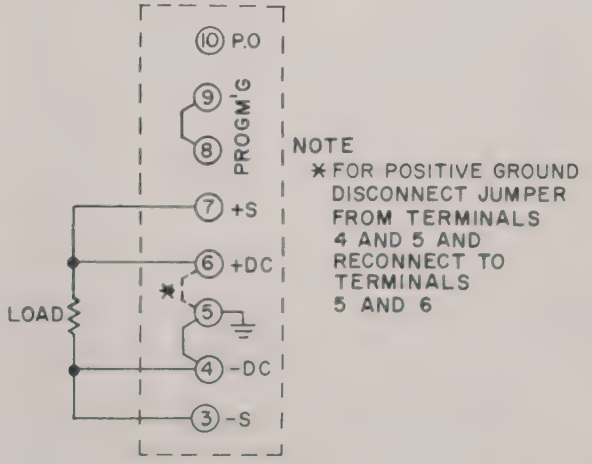
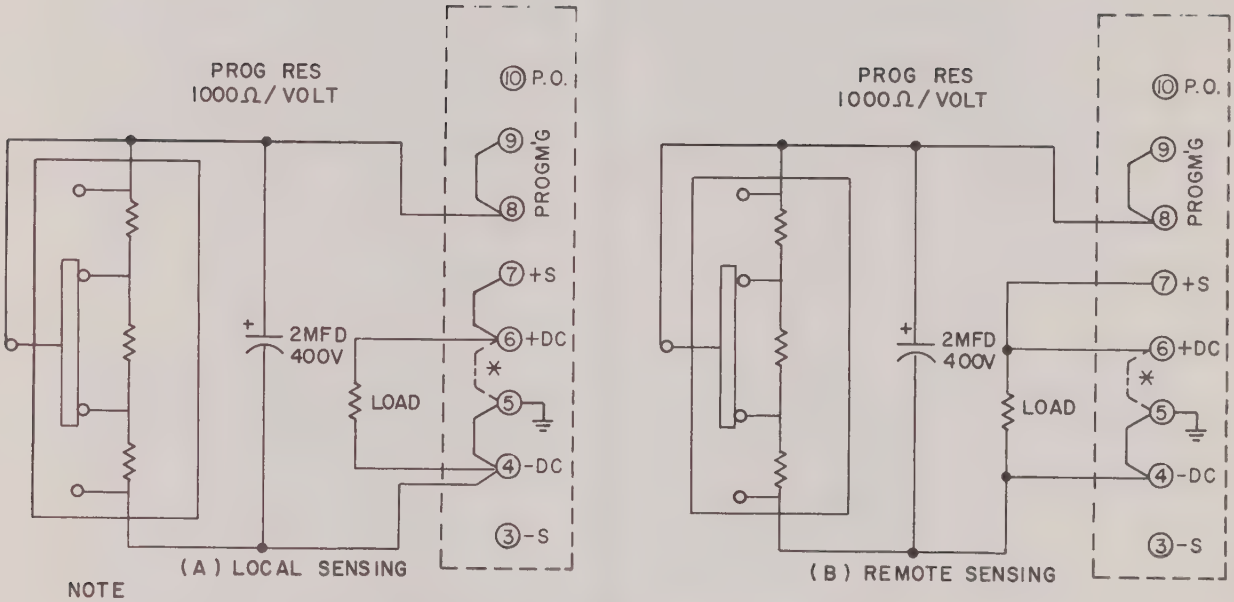
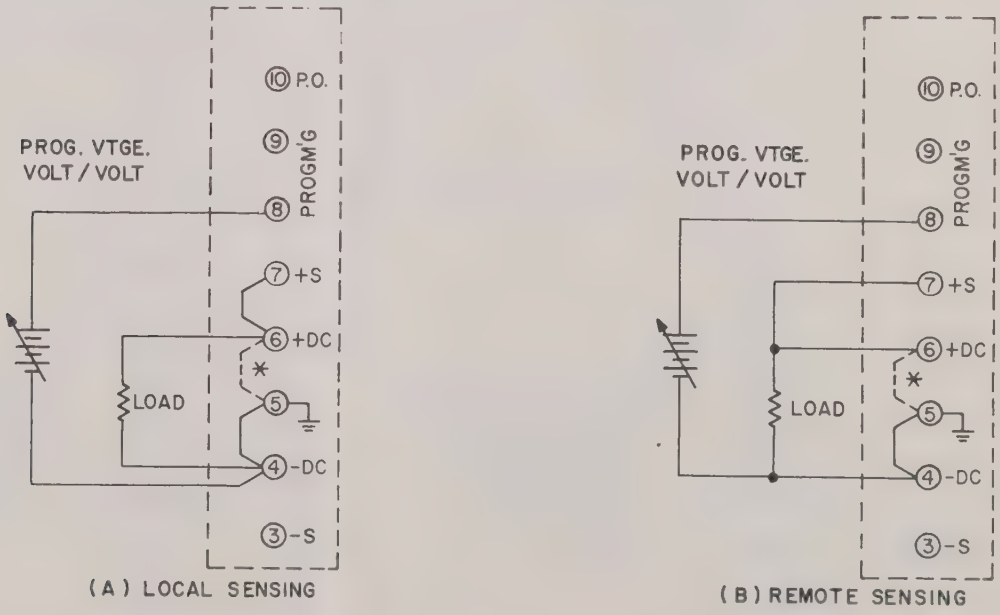


FIGURE 4. FOUR-WIRE CONNECTION



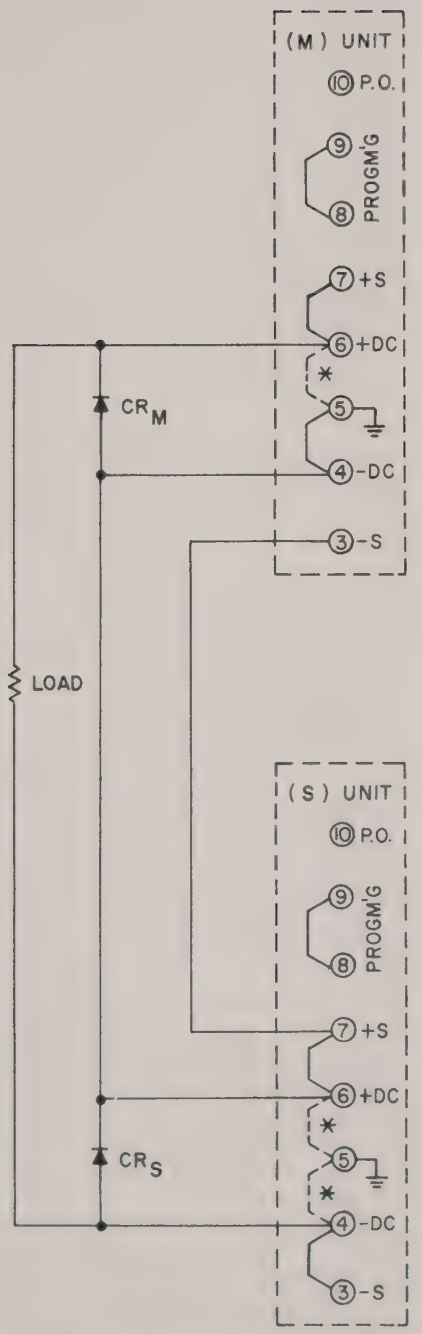
NOTE
* FOR POSITIVE GROUND DISCONNECT JUMPER FROM TERMINALS 4 AND 5 AND RECONNECT TO TERMINALS 5 AND 6

FIGURE 5. PROGRAMMED VOLTAGE WITH EXTERNAL RESISTOR

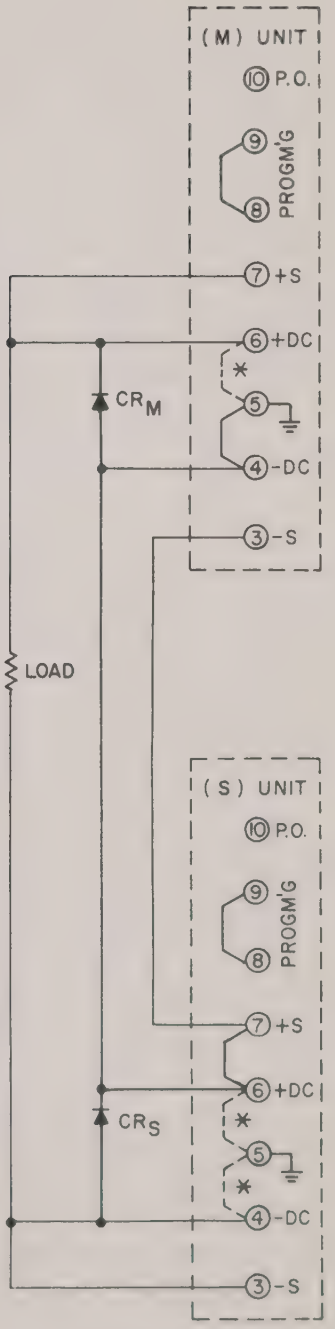


NOTE
* FOR POSITIVE GROUND DISCONNECT JUMPER FROM TERMINALS 4 AND 5 AND RECONNECT TO TERMINALS 5 AND 6

FIGURE 6. PROGRAMMED VOLTAGE WITH EXTERNAL PROGRAMMING VOLTAGE SOURCE



(A) LOCAL SENSING

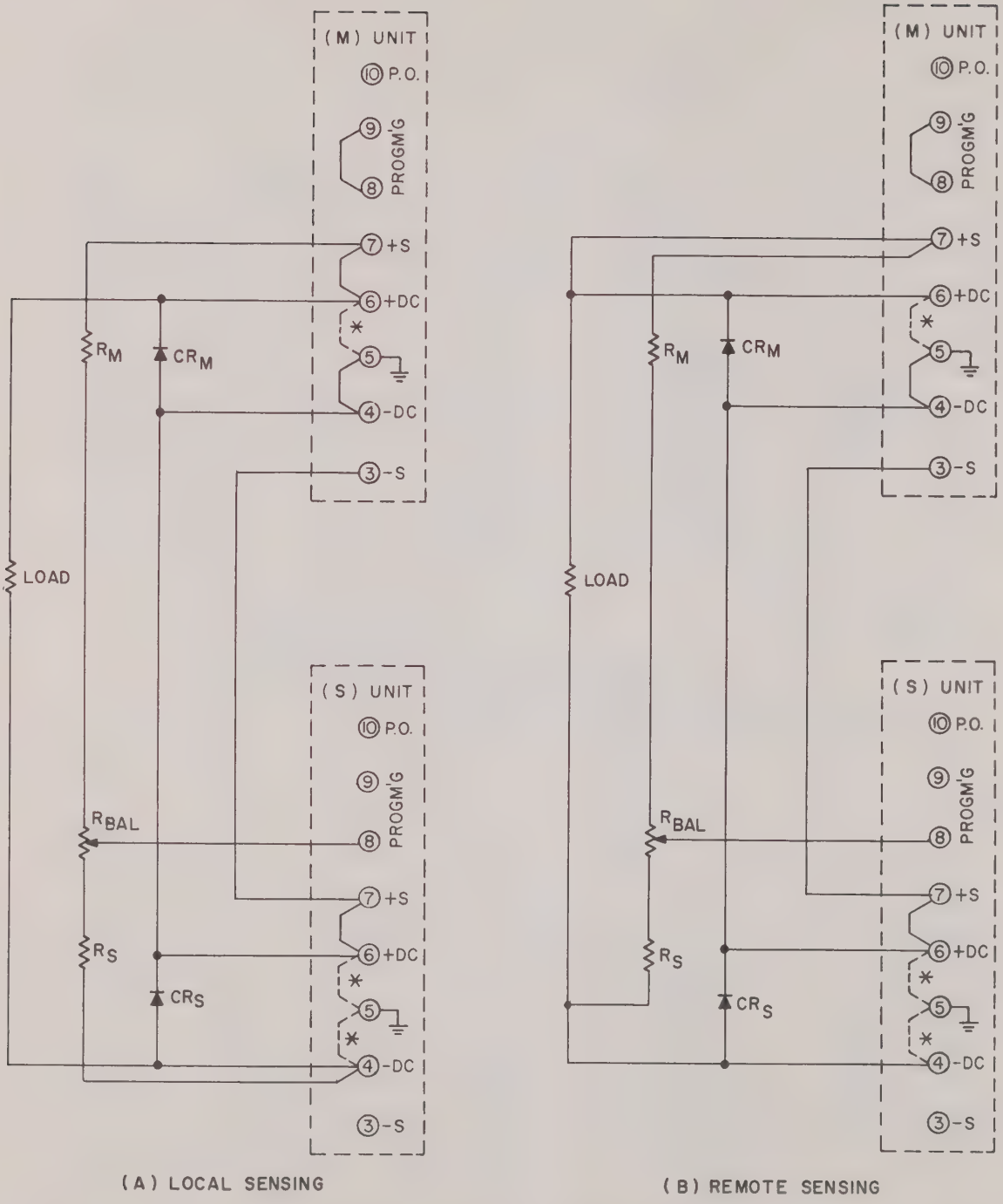


(B) REMOTE SENSING

NOTE

* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 4 AND 5 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

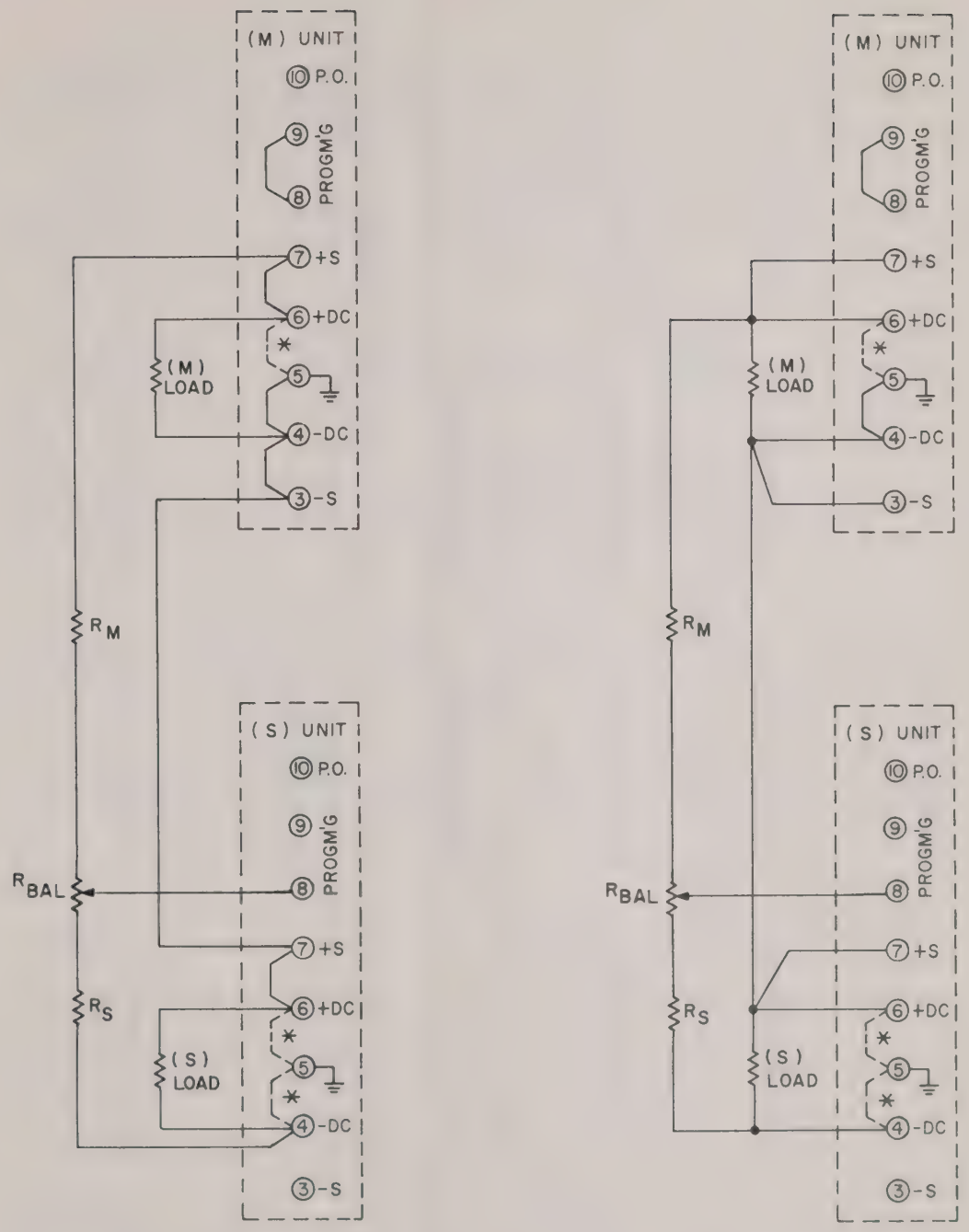
FIGURE 7. SERIES CONNECTION



NOTE

* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 4 AND 5 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

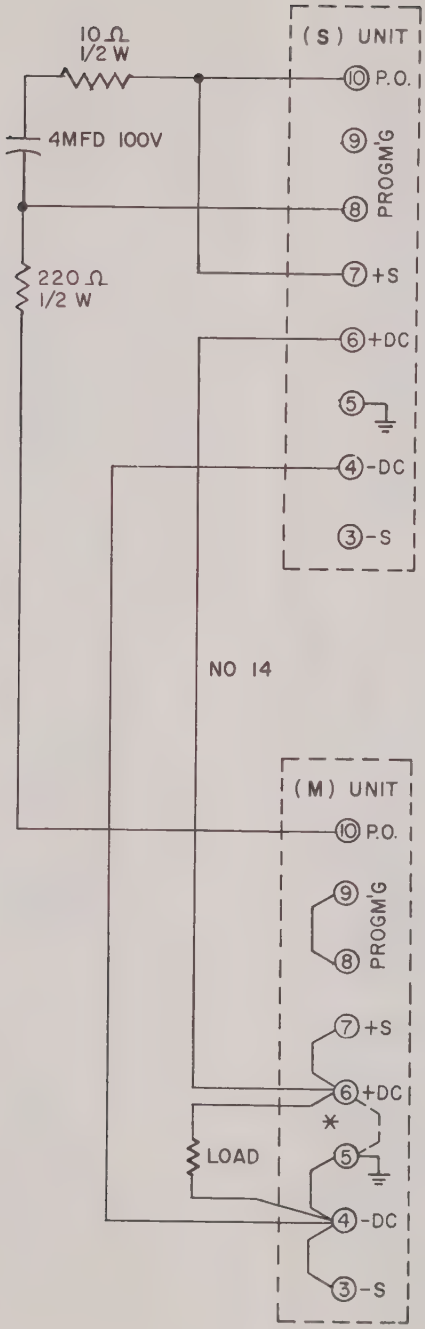
FIGURE 8. AUTO-SERIES CONNECTION



NOTE

* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 4 AND 5 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 9. DUAL OUTPUT, AUTO-TRACKING



NOTE

* FOR POSITIVE GROUND DISCONNECT JUMPER FROM TERMINALS 4 AND 5 AND RECONNECT TO TERMINALS 5 AND 6

FIGURE 10. PARALLEL CONNECTION, LOCAL SENSING

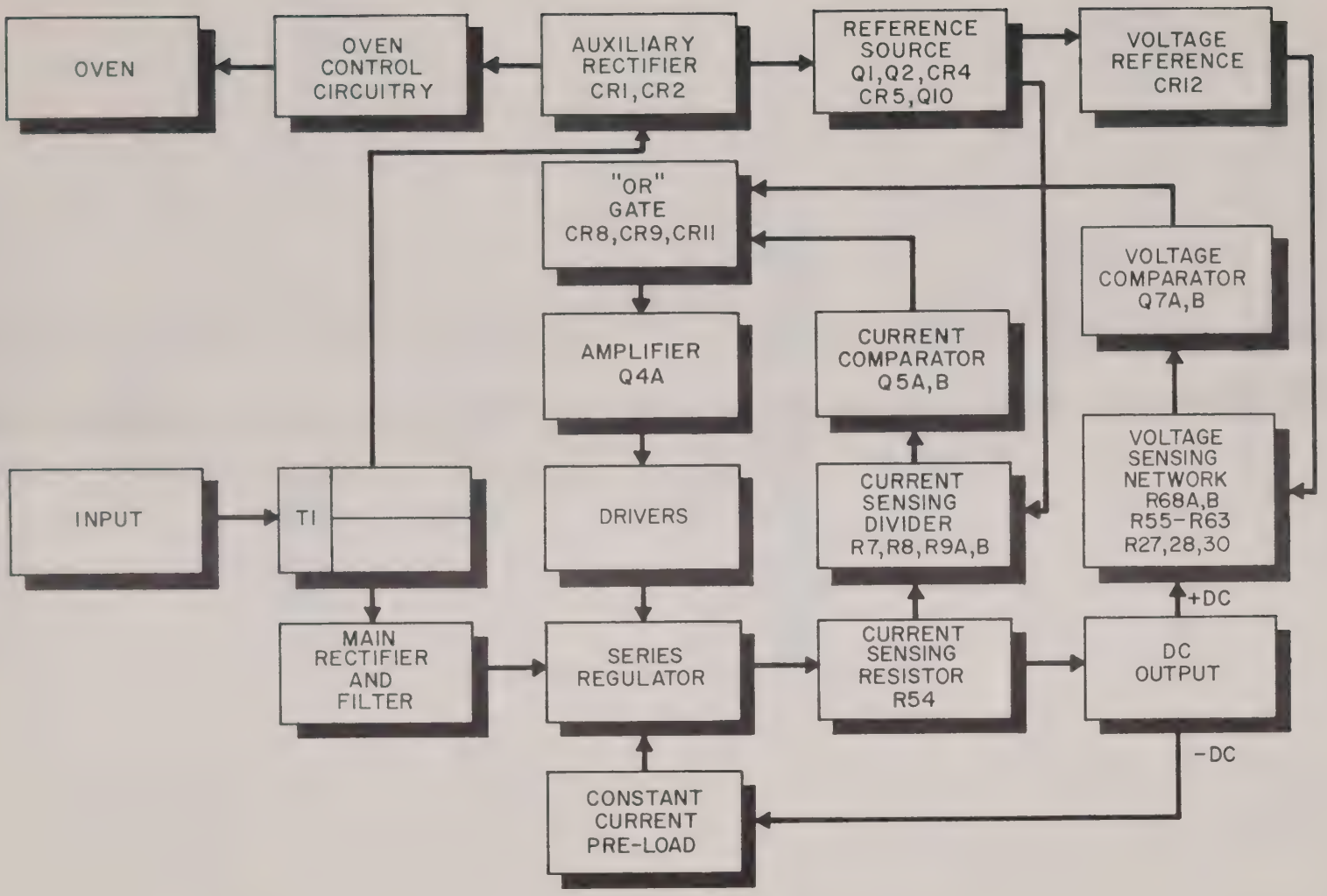
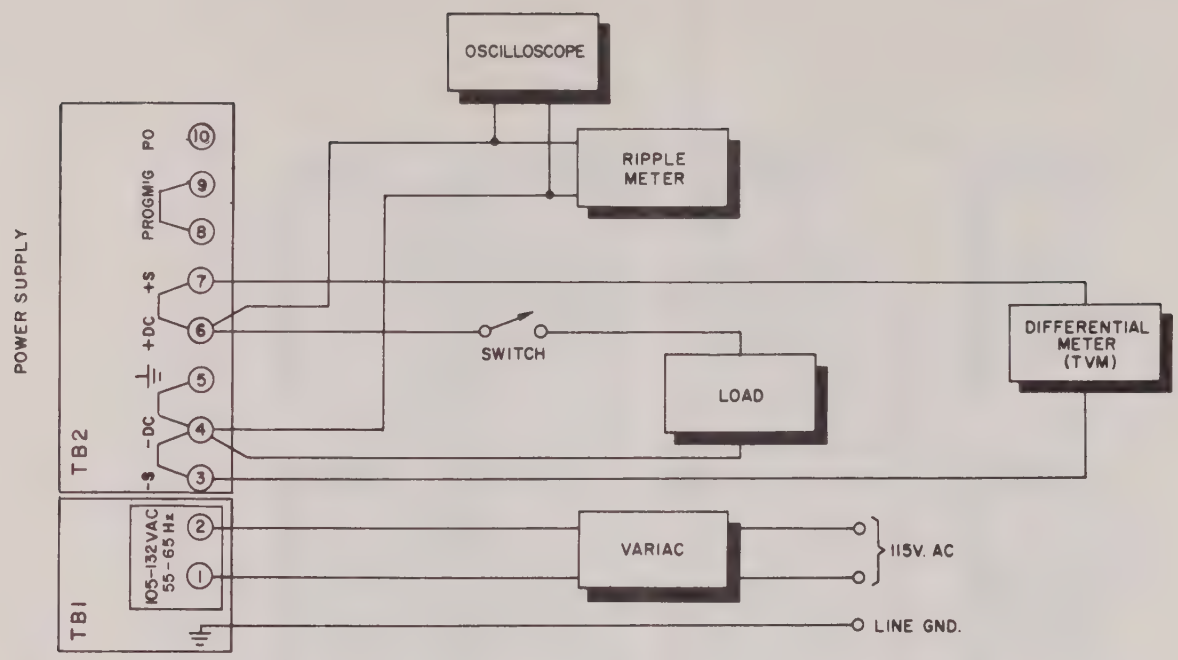


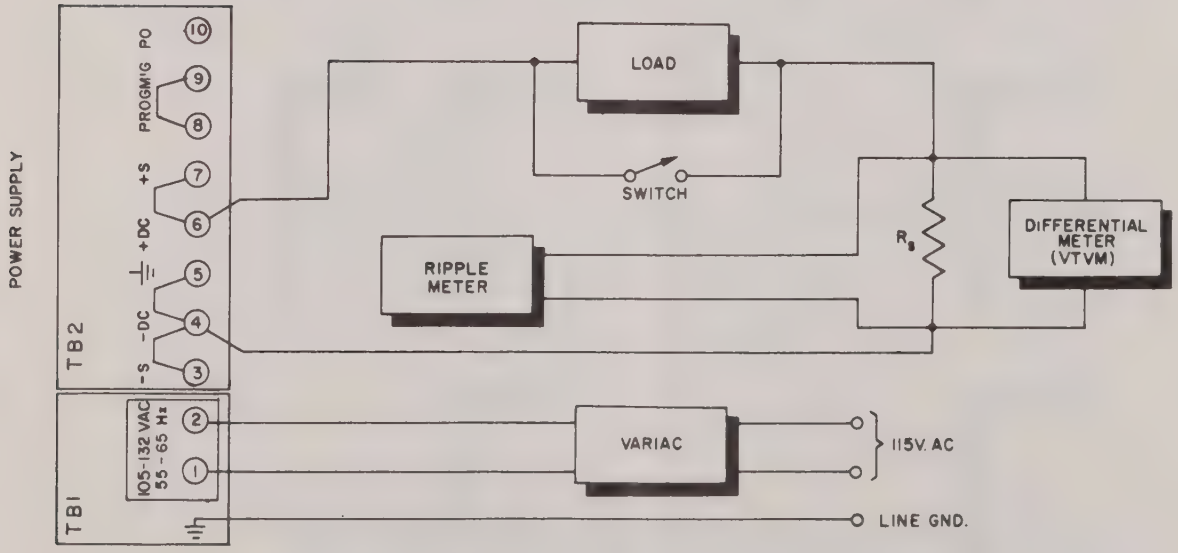
FIGURE 11. TYPICAL BLOCK DIAGRAM



NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

Figure 12. Test Connections For Constant Voltage Performance Checks



NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

Figure 13. Test Connections For Constant Current Performance Checks

GENERAL DESCRIPTION

Rack adapter LRA-1 is designed for use in equipment racks where ruggedized mounting of units is required. The adapter can be used with or without chassis slides.

Rack adapter LRA-2 is designed for simple applications of rack installation where chassis slides and ruggedized mounting of equipment are not required.

Both rack adapter LRA-1 and LRA-2 can be used to install 1/4-rack or 1/2-rack power supply units into equipment racks. Each adapter can accept various combinations of 1/4 and 1/2-rack units up to four 1/4-rack units or two 1/2-rack units.

INSTALLATION OF 1/2 RACK UNITS INTO LRA-1

To install 1/2-rack power supply units, remove slide numbers 2 and 3 and/or 6 and 7, together with securing hardware and associated slide bar nut.

Using slide screws and slide bar nuts that were removed, store removed slides on the frame at the rear of the adapter where screw clearance holes are provided for securing each slide to the adapter.

SHIPMENT OF UNITS MOUNTED IN LRA-1

To protect the unit against damage from shock and vibrations when transporting adapter with installed units, eight universal tie-down mounting holes, located in the adapter base, at the rear of the rack adapter, are used to secure 1/4-rack and/or 1/2-rack units into the rack adapter. Secure each unit using two 6-32 x 5/8 screws, two lockwashers and two spacers installed from the bottom side of the rack adapter. See detail A for typical securing hardware. Eight spacers are supplied with rack adapter LRA-1.

RUGGEDIZED MOUNTING

When ruggedized mounting of units is required, follow the procedure described for SHIPMENT OF UNITS MOUNTED IN LRA-1. See detail A for typical securing hardware.

MOUNTING CHASSIS SLIDES

Mount chassis slides using the following hardware. To assure unrestricted mounting of units into the adapter designated screw lengths must not be exceeded. Insert screws into designated holes and secure slide in position using long bar nut supplied with rack adapter LRA-1.

CHASSIS TRAK NO. CTS.-116:
10-32 x 7/16 fl-hd (82°);
use A holes.

JONATHAN NO. 130 QD:
6-32 x 1/2 fl-hd (82°);
use B and C holes.

GRANT PULLEY NO. 4435:
6-32 x 5/16 fl-hd (100°);
use B and D holes.

USING BLANK PANELS AND BLANK CHASSIS

Blank front panels Model LBP-10 and LBP-20 are available for covering any 1/4-rack or 1/2-rack opening respectively. The blank panels can be used with rack adapter LRA-1 and LRA-2 whenever a 1/4-rack or 1/2-rack space in the adapter is not occupied by a unit. Secure each panel in position using four 6-32 x 3/8 panhead screws supplied with the rack adapter.

Paneled blank chassis Models LBC-10 (1/4-rack size) and LBC-20 (1/2-rack size) are available for any 1/4-rack or 1/2-rack equipment design package. These blank chassis enable the user of rack adapters LRA-1 and LRA-2 to design system equipment that can be packaged on ready-made chassis that are compatible with existing system components. Both blank chassis can be used with rack adapters LRA-1 and LRA-2.

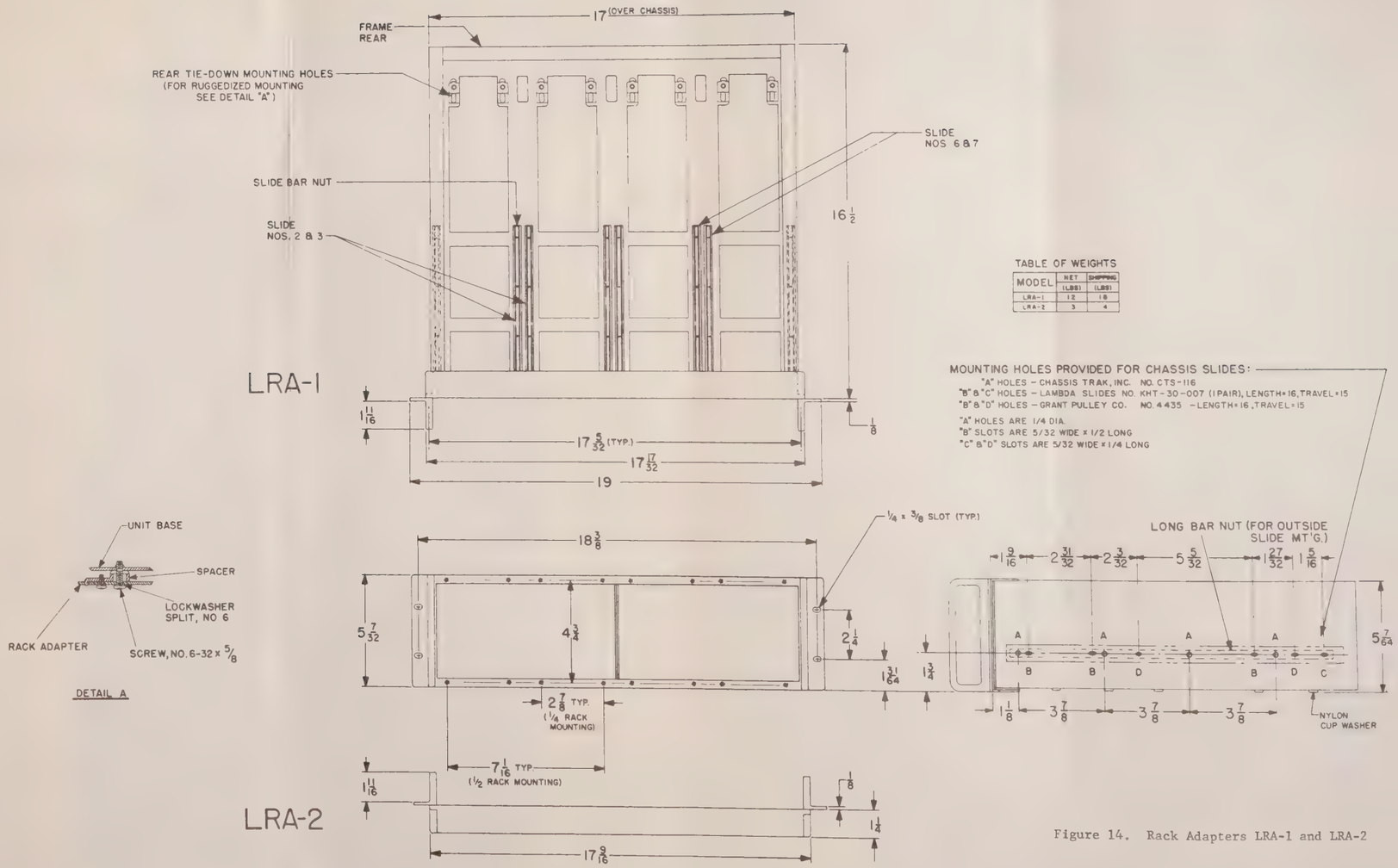


Figure 14. Rack Adapters LRA-1 and LRA-2

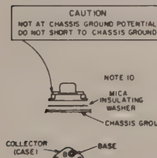
SCB-602

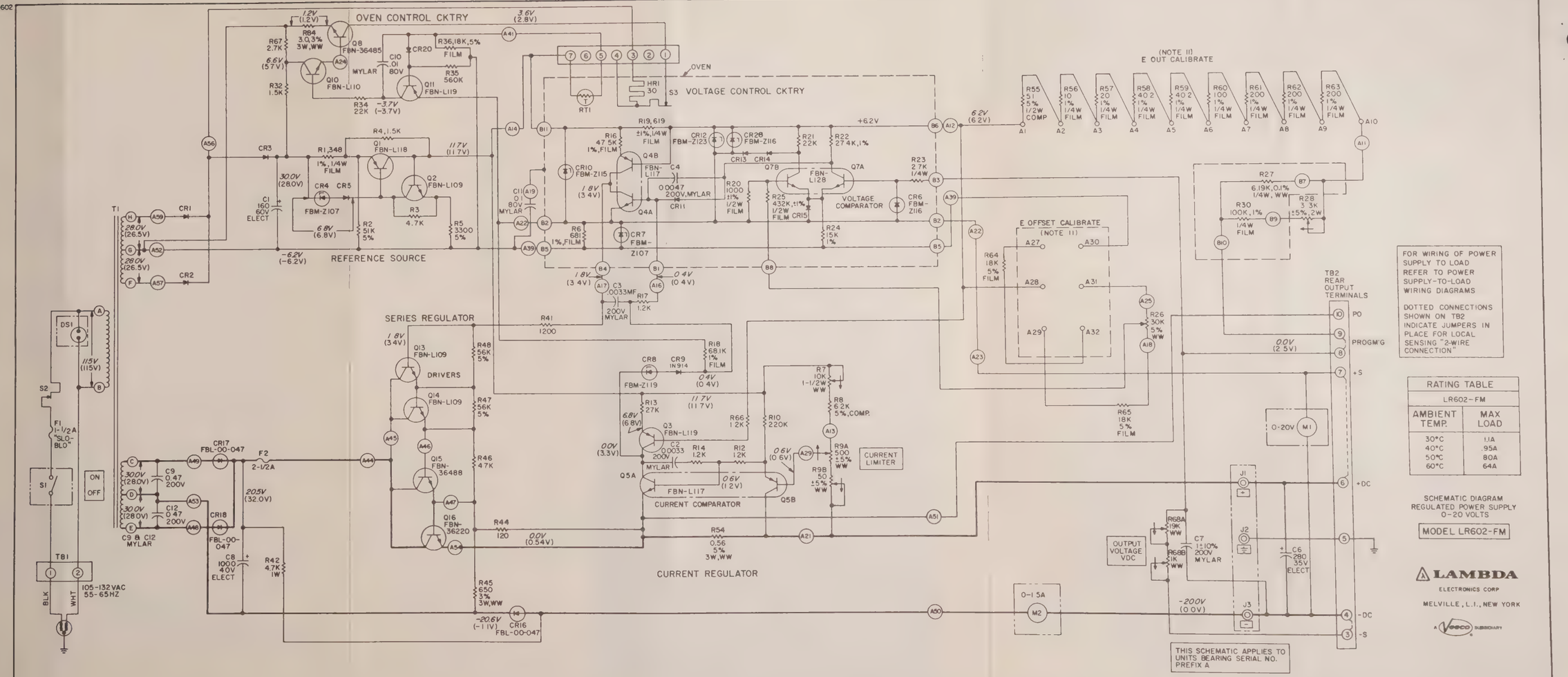
NOTES

1 RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED
2 RESISTOR WATTAGE 1/4 WATT; RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED
3 RESISTOR TOLERANCES: COMPOSITION ±10%; WIREWOUND ±2% UNLESS OTHERWISE NOTED.
4 CAPACITOR TOLERANCES: ELECTROLYTIC, -10% +100%, TANTALUM, ±20%, PAPER, ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10%, UNLESS OTHERWISE NOTED
5 SYMBOLS
- ↑ INDICATES CLOCKWISE ROTATION OF SHAFT.
- ⏚ INDICATES CONNECTION TO CHASSIS
- ⊛ INDICATES ADJUSTMENT OR CALIBRATION CONTROL
- □ INDICATES ACTUAL UNIT MARKING.
- [ ] INDICATES FRONT-PANEL MOUNTED COMPONENT
- * INDICATES FACTORY ADJUSTMENT.
- ◯ INDICATES TRANSFORMER LUG TERMINAL.
- ▶| THIS DIODE IS LAMBDA PART NO FBL-00-030; CAN BE REPLACED WITH STANDARD TYPE IN4245, IN5059 OR IN4002 DIODE.

6 CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS
A CONSTANT VOLTAGE
READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION
INPUT 115 VAC, 60 HZ
OUTPUT MAX RATED VOLTAGE, OUTPUT CURRENT ZERO
B CONSTANT CURRENT
READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION
INPUT 115 VAC, 60 HZ, 30° AMBIENT
OUTPUT 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT)
INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED
DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM. 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED
7 DESIGNATIONS ARE LAMBDA PART NUMBERS
8 ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD AND PRINTED WIRING BOARDS.
9 ○ INDICATES INTERNAL POINT ON P.C. BOARD
10 COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO. 340 SILICONE GREASE
11 JUMPERS USED TO CALIBRATE THIS NETWORK ARE NOT SHOWN AND ARE UNIQUE TO EACH UNIT.

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND





RATING TABLE	
LR602-FM	
AMBIENT TEMP.	MAX LOAD
30°C	11A
40°C	95A
50°C	80A
60°C	64A

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY
0-20 VOLTS

MODEL LR602-FM

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A

LAMBDA
ELECTRONICS CORP
MELVILLE, L.I., NEW YORK
A VOLTRONICS SUBSIDIARY

SCB-603

NOTES

1 RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED
2 RESISTOR WATTAGE 1/4 WATT, RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED
3 RESISTOR TOLERANCES COMPOSITION ±10%, WIREWOUND ±2% UNLESS OTHERWISE NOTED
4 CAPACITOR TOLERANCES ELECTROLYTIC -10% +100%, TANTALUM ±20%, PAPER ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10%, UNLESS OTHERWISE NOTED
5 SYMBOLS
- INDICATES CLOCKWISE ROTATION OF SHAFT
- INDICATES CONNECTION TO CHASSIS
- INDICATES ADJUSTMENT OR CALIBRATION CONTROL
- INDICATES ACTUAL UNIT MARKING
- INDICATES FRONT-PANEL MOUNTED COMPONENT
- * INDICATES FACTORY ADJUSTMENT.
- INDICATES TRANSFORMER LUG TERMINAL
- THIS DIODE IS LAMBDA PART NO FBL-00-030, CAN BE REPLACED WITH STANDARD TYPE IN4245, IN5059 OR IN4002 DIODE.

6 CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS
A CONSTANT VOLTAGE
READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION
INPUT 115 VAC, 60 HZ
OUTPUT MAX RATED VOLTAGE, OUTPUT CURRENT ZERO
B CONSTANT CURRENT
READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION
INPUT 115 VAC, 60 HZ, 30° AMBIENT
OUTPUT 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT)
INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED
DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED
7 DESIGNATIONS ARE LAMBDA PART NUMBERS
8 ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD AND PRINTED WIRING BOARDS.
9 ○ INDICATES INTERNAL POINT ON P.C. BOARD.
10 COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO. 340 SILICONE GREASE.
11 JUMPERS USED TO CALIBRATE THIS NETWORK ARE NOT SHOWN AND ARE UNIQUE TO EACH UNIT.

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND

NOTE 10
MICA INSULATING WASHER
CHASSIS GROUND

TRANSISTOR PIN VIEW
COLLECTOR (CASE) B BASE E EMITTER

DUAL TRANSISTOR PIN VIEW
Q4, Q5, Q7

OVEN CONTROL CKTRY
OVEN
S3 VOLTAGE CONTROL CKTRY
REFERENCE SOURCE
SERIES REGULATOR
DRIVERS
CURRENT REGULATOR
CURRENT COMPARATOR
VOLTAGE COMPARATOR
CURRENT LIMITER
E OFFSET CALIBRATE (NOTE 11)
(NOTE 11) E OUT CALIBRATE
TB2 REAR OUTPUT TERMINALS
PO
PROGM'G
+S
+DC
-DC
-S
105-132 VAC 55-65 HZ
115 VAC (115 VAC)
OUTPUT VOLTAGE VDC
0-40V M1
0-1A M2

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO POWER SUPPLY-TO-LOAD WIRING DIAGRAMS

DOTTED CONNECTIONS SHOWN ON TB2 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING "2-WIRE CONNECTION"

RATING TABLE LR603-FM	
AMBIENT TEMP.	MAX LOAD
30°C	0.60A
40°C	0.50A
50°C	0.42A
60°C	0.33A

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY
0-40 VOLTS

MODEL LR603-FM

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A

LAMBDA ELECTRONICS CORP
MELVILLE, L.I., NEW YORK
A Veeco SUBSIDIARY

SCB-605

NOTES:

1. RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED.
2. RESISTOR WATTAGE 1/4 WATT, RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: COMPOSITION ±10%; WIREWOUND ±2% UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC, -10% +100%, TANTALUM, ±20%, PAPER, ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10%, UNLESS OTHERWISE NOTED.
5. SYMBOLS:
   - ⏚ INDICATES CLOCKWISE ROTATION OF SHAFT.
   - ⏚ INDICATES CONNECTION TO CHASSIS
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL
   - INDICATES ACTUAL UNIT MARKING.
   - INDICATES FRONT-PANEL MOUNTED COMPONENT.
   - * INDICATES FACTORY ADJUSTMENT.
   - ◯ INDICATES TRANSFORMER LUG TERMINAL.
   - THIS DIODE IS LAMBDA PART NO FBL-00-030; CAN BE REPLACED WITH STANDARD TYPE IN4245, IN5059 OR IN4002 DIODE.
6. CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS.
   - A CONSTANT VOLTAGE
     - READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION
     - INPUT: 115 VAC, 60 HZ
     - OUTPUT: MAX RATED VOLTAGE, OUTPUT CURRENT ZERO
   - B CONSTANT CURRENT
     - READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION
     - INPUT: 115 VAC, 60 HZ, 30° AMBIENT.
     - OUTPUT: 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT)

   INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED.

   DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED.
7. DESIGNATIONS ARE LAMBDA PART NUMBERS.
8. ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD AND PRINTED WIRING BOARDS.
9. ○ INDICATES INTERNAL POINT ON P.C. BOARD.
10. COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO 340 SILICONE GREASE.
11. JUMPERS USED TO CALIBRATE THIS NETWORK ARE NOT SHOWN AND ARE UNIQUE TO EACH UNIT.

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND

NOTE 10
MICA INSULATING WASHER
CHASSIS GROUND

COLLECTOR (CASE) — BASE — EMITTER
TRANSISTOR, PIN VIEW

DUAL TRANSISTOR PIN VIEW
Q4, Q8, Q7

OVEN CONTROL CKTRY

VOLTAGE CONTROL CKTRY

OVEN

REFERENCE SOURCE

DRIVERS

SERIES REGULATOR

CURRENT LIMITER

CURRENT COMPARATOR

VOLTAGE COMPARATOR

(NOTE 11) E OUT CALIBRATE

E OFFSET CALIBRATE (NOTE 11)

TB2 REAR OUTPUT TERMINALS

PO
PROGM'G
+S
+DC
-DC
-S

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO POWER SUPPLY-TO-LOAD WIRING DIAGRAMS

DOTTED CONNECTIONS SHOWN ON TB2 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING "2-WIRE CONNECTION"

RATING TABLE LR605-FM	
AMBIENT TEMP.	MAX LOAD
30°C	0.23A
40°C	0.20A
50°C	0.17A
60°C	0.14A

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY
0-120 VOLTS

MODEL LR605-FM

LAMBDA ELECTRONICS CORP
MELVILLE, L.I., NEW YORK
A Vesco SUBSIDIARY

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A

SCB-606

NOTES

1. RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED.
2. RESISTOR WATTAGE 1/4 WATT. RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: COMPOSITION ±10%; WIREWOUND ±2% UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC, -10% +100%; TANTALUM, ±20%; PAPER, ±10%; CERAMIC, ±20%; MICA, ±20%; MYLAR, ±10%; UNLESS OTHERWISE NOTED.
5. SYMBOLS:
   - ⏚ INDICATES CLOCKWISE ROTATION OF SHAFT.
   - ⏚ INDICATES CONNECTION TO CHASSIS.
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - □ INDICATES ACTUAL UNIT MARKING.
   - [ ] INDICATES FRONT-PANEL MOUNTED COMPONENT.
   - * INDICATES FACTORY ADJUSTMENT.
   - ◯ INDICATES TRANSFORMER LUG TERMINAL.
   - ▶| THIS DIODE IS LAMBDA PART NO. FBL-00-030, CAN BE REPLACED WITH STANDARD TYPE IN4245, IN5059 OR IN4002 DIODE.
6. CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS.
   - A. CONSTANT VOLTAGE
     READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION.
     INPUT: 115 VAC, 60 HZ.
     OUTPUT: MAX RATED VOLTAGE, OUTPUT CURRENT ZERO.
   - B. CONSTANT CURRENT.
     READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION.
     INPUT: 115 VAC, 60 HZ, 30° AMBIENT.
     OUTPUT: 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT).

   INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED.

   DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM. 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED.
7. DESIGNATIONS ARE LAMBDA PART NUMBERS.
8. ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD AND PRINTED WIRING BOARDS.
9. ○ INDICATES INTERNAL POINT ON P.C. BOARD.
10. COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO. 340 SILICONE GREASE.
11. JUMPERS USED TO CALIBRATE THIS NETWORK ARE NOT SHOWN AND ARE UNIQUE TO EACH UNIT.

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND

NOTE 10
MICA INSULATING WASHER
CHASSIS GROUND

COLLECTOR (CASE) BASE EMITTER
TRANSISTOR, PIN VIEW

DUAL TRANSISTOR PIN VIEW Q4, Q5, Q7

OVEN CONTROL CKTRY

OVEN

S3 VOLTAGE CONTROL CKTRY

REFERENCE SOURCE

DRIVERS

SERIES REGULATOR

CURRENT COMPARATOR

VOLTAGE COMPARATOR

CURRENT LIMITER

E OUT CALIBRATE (NOTE 11)

E OFFSET CALIBRATE (NOTE 11)

TB2 REAR OUTPUT TERMINALS

PO
PROGM'G
+S
+DC
-DC
-S

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO POWER SUPPLY-TO-LOAD WIRING DIAGRAMS

DOTTED CONNECTIONS SHOWN ON TB2 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING "2-WIRE CONNECTION"

RATING TABLE	
LR606-FM	
AMBIENT TEMP.	MAX LOAD
30°C	0.080A
40°C	0.072A
50°C	0.065A
60°C	0.060A

SCHEMATIC DIAGRAM
REGULATED POWER SUPPLY
0-250 VOLTS

MODEL LR606-FM

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A

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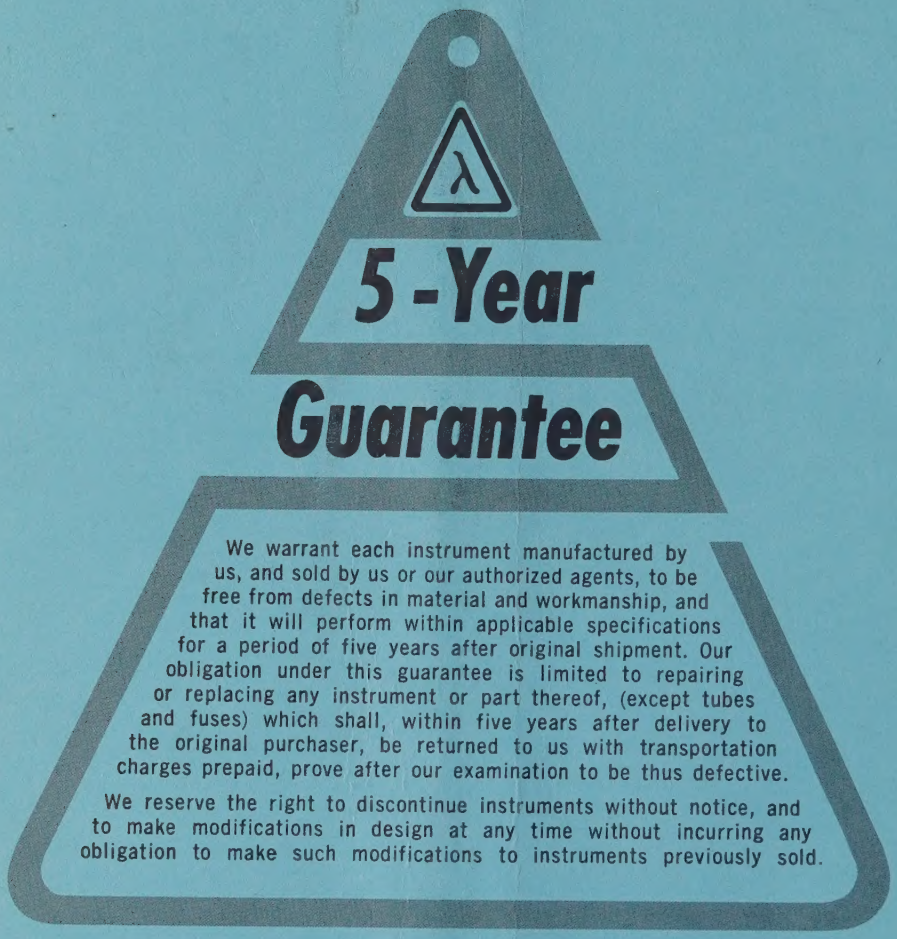

5-Year Guarantee

We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of five years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except tubes and fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.

We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

LAMBDA ELECTRONICS CORP.

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